Algebra acts as a gatekeeper for high school graduation and post-secondary success. Students who pass Algebra 1 by the end of ninth grade are more likely to take advanced mathematics courses, graduate from high school, and succeed in college. Yet persistent inequities in access to rigorous algebra due to issues of placement, preparation, and quality of instruction have kept the gate closed for a large proportion of students, particularly minority and low-income students. In response, “Algebra for All” policies have been implemented whereby all students are required to take Algebra 1 by a designated grade level—typically eighth or ninth grade. While such policies are on target in their intention to increase the number of students who successfully complete Algebra 1 in a timely way, evidence also shows that for too many students, these policies by themselves have neither increased mathematics achievement nor advanced greater opportunity. Rather, they often result in the watering down of Algebra 1 content and significantly increase the number of students who fail the course. These consequences are concentrated among underprepared students, whom the policies were designed to serve in the first place. As such, the worthy goals of Algebra for All may only be realized when a rigorous approach to Algebra is maintained for all students, and when necessary systems are in place to prepare and support all students to be successful. The Common Core State Standards for Mathematics (CCSS-M) now provides clearer and more rigorous expectations for the algebra content all students should learn, but the articulation of such standards is only a starting point. Algebra policy, therefore, should include provisions for equitably maintaining this level of rigor for all students, while providing a system of supports to: (1) better prepare students to succeed before taking Algebra 1; (2) enhance learning opportunities for underprepared learners during Algebra 1; and (3) enhance teaching capacity to support all learners, particularly those who are underprepared to succeed in Algebra 1.
INTRODUCTION

For students who are underprepared to succeed in Algebra 1, passing the course can represent an overwhelming challenge. Yet, success in Algebra 1 is no less crucial for these underprepared students than it is for students who are better prepared to succeed. A dilemma emerges: policies that promote successful completion of Algebra by all students are weighed against their potential to increase failure rates for underprepared students, and the consequences failure can have on these students’ academic trajectories. In the current context of secondary education and in light of the relationship of Algebra to college and career readiness, however, we hold to the position that all students should take algebra in a timely manner.

WHY IS SUCCESSFUL COMPLETION OF ALGEBRA 1 IMPORTANT FOR ALL STUDENTS?

Education policy nationwide continues on a trend toward raising mathematics requirements for high school graduation. In 2013, 42 states, including Illinois, required successful completion of at least three years of mathematics, and 16 of these states required completion of four years. These numbers will likely increase in the next few years as pending legislation is enacted in several states. By contrast, in 2001 only 28 states required three years or more of mathematics for graduation, and only 4 states required four years. Whether or not Algebra 1 is explicitly stated as a course requirement (it is in 23 states), the completion of the course—and in many cases the passing of a related end-of-course exam—tends to be the critical step in meeting these increasingly rigorous graduation requirements. In addition, 45 states, also including Illinois, have adopted the Common Core State Standards for Mathematics (CCSS-M)—written specifications of what students should know and be able to do in mathematics in various grades. The algebra standards in CCSS-M provide a clear and coherent articulation of algebra students should learn—in elementary grades as well as in high-school Algebra 1 and Algebra 2 courses.

1 The term “years” is used for clarity in place of Carnegie Units, in which the data was originally presented. One Carnegie Unit generally equates to credit received for successful completion of a two-semester, credit-bearing course in secondary school.


3 In some settings, a sequence of Integrated Mathematics replaces the traditional high school mathematics sequence. This Integrated sequence is currently being proposed by the Illinois State Board of Education as one model for implementing CCSS-M in grades 9-12. Because Integrated Mathematics 1 includes a concentrated focus on many of the concepts similar to those found in Algebra 1, the issues discussed in this brief can be similarly applied to Integrated Mathematics 1.

for Algebra 1, with the intention of increasing students’ preparedness to take more advanced mathematics courses and helping students obtain the skills needed to succeed in college and the workplace.

In light of these trends, Algebra 1 retains its role as a gatekeeper for high school graduation and post-secondary success, and the urgency of passing through continues to intensify. High school algebra is widely considered a key step along the path to college and career readiness. Because of increased graduation requirements, failing Algebra 1 puts students at significant risk of not completing high school. In Chicago Public Schools (CPS), students who earned 5 credits and failed no more than one course in ninth grade were over 3.5 times more likely to graduate from high school in four years than students who did not achieve this benchmark. Thus, the widespread difficulties faced by many students in passing Algebra 1 establishes it as a critical link related to success rates in high school.

**THE CHALLENGE OF ALGEBRA**

Yet, in CPS and elsewhere, Algebra 1 continues to generate the highest failure rate of any high school course. The reasons for this are complex and difficult to isolate, but several themes have emerged from ongoing research in mathematics education that can provide guidance in the design of policy and practice. With respect to course content, Algebra 1 has historically represented an important transition point in the learning of mathematics, requiring the use of generalized models, mathematical abstractions, and understandings of variables and symbols, all of which are particularly challenging for many students. Simply stated, content associated with Algebra 1 is notoriously difficult compared with the number and operations concepts concentrated in earlier grades. Research has also indicated that many eighth and ninth grade students who are required to take Algebra 1 are also underprepared and need more support to succeed because of weak foundations in prerequisite concepts. As many of these students enter their first algebra course, they experience early, reinforcing patterns of failure, which can lead to the belief they will not be able to earn a high school diploma. Without effective forms of intervention and support, these patterns of failure can cause students to fall further behind and eventually drop out of school. But what kinds of support are needed for under-prepared students to succeed in this high-stakes course? How can algebra policy help provide these supports as a way to not only increase graduation rates, but to truly help prepare students for college and post-secondary success?

To investigate these questions amidst these current challenges, this brief examines evidence related to algebra policies and their effects on students, particularly those who are underprepared to succeed. First, the policy landscape of algebra is examined. This section focuses on both the mathematics content that students are required to learn and research on the effects of these requirements. Second, this brief analyzes additional research on mathematics education and offers three principles that bear directly on improving students’ success in algebra: (1) Students need systematic exposure to algebra beginning early in their education and extending through high school; (2) underprepared students need targeted, structured support to succeed in a rigorous Algebra 1 course; and (3) increasing students’ success requires enhanced teaching capacity that needs to be addressed in teacher preparation programs as well as in

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in-service professional development. Finally, this brief poses a set of recommendations for improving mathematics education policies and practices in algebra.

THE ALGEBRA POLICY LANDSCAPE

In order to graduate from high school, Illinois currently requires that students must complete three credits in mathematics, including Algebra 1 and a course in geometry.10 This requirement is the result of legislation enacted in 2005, which increased overall graduation requirements in core disciplines with the intention of ramping up the academic preparation of Illinois graduates. Algebra 1 is the introductory course in a typical secondary mathematics sequence of Algebra 1, Geometry, and Algebra 2. Most students take Algebra 1 in ninth grade, though increasing numbers of students take it in eighth grade, and some as early as sixth grade. Guidance from the Illinois State Board of Education (ISBE) on implementing the graduation requirements cites evidence that high school students who take rigorous courses are more prepared to graduate, succeed in college, and participate in the workforce.11

One response to this requirement has been to delay underprepared students’ enrollment in Algebra to beyond ninth grade in order to provide more coursework in pre-algebra skills. Evidence, however, shows that this approach does not work. Students typically continue to struggle learning the same pre-algebra skills from the middle-grades curriculum, taught using the same approaches. Consequently, they continue to fall further behind and eventually disengage from mathematics altogether.12 Another approach has been to slow the pace of algebra for underprepared students by stretching the curriculum over a two-year span across ninth and tenth grades. While this approach does move underprepared students forward in the high school curriculum, it does so at the cost of setting them back by a full year, rather than allowing them to catch up to their peers.

ALGEBRA FOR ALL: INTENTIONS AND CHALLENGES

To further ensure access to challenging mathematics for all students, some state and district policies require that Algebra 1 be taken by a specified grade level—typically ninth grade, but in some cases eighth grade—as a measure to ensure students’ preparedness for more advanced mathematics.13

Such districts notably include large urban districts, such as Chicago, Philadelphia, Los Angeles, Baltimore, and Milwaukee, where large inequities exist in the number of minority and low-income students taking advanced mathematics classes. Research on the effects of these policies, however, points to both positive and negative consequences.14 On the positive side, Algebra for All has allowed more students to enroll and successfully complete Algebra 1, which in turn opens opportunities for challenging coursework in mathematics, and increases the likelihood of graduation, college enrollment, and postsecondary success.15 On the negative side, these policies do not provide for the supports needed by underprepared students to succeed in Algebra 1.

A policy that has been in place in CPS since 1997 mandates that all students take Algebra 1 by the end of ninth grade. The policy’s aim is to raise the bar on mathematics for all students on the premise that ramping up to a college-preparatory curriculum levels the playing field and improves achievement, particularly among minority and low-income students.

11 Illinois State Board of Education, State Graduation Requirements.
Research indicates, however, that the policy has neither raised standardized test scores in mathematics nor increased the likelihood of students attending college. In addition, Algebra 1 has continued to produce the highest failure rate of any single course in the years following the enactment of the policy.\(^\text{16}\)

In the state of California, Algebra for All has been a major focus of statewide policy since the late 1990s, which established as one of its central goals the enrollment of all students in Algebra 1 by eighth grade. The result has been a drastic increase in the percentage of California eighth-graders taking Algebra 1: from 16% in 1999, to 32% in 2003, to 51% in 2008. Pass rates of eighth-graders on the Algebra 1 California Standards Test (CST) assessment, however, reveals a mix of positive results and dire consequences. While 1.8 times as many eighth-graders passed the Algebra 1 CST in 2008 as compared to 2003, 1.5 times as many eighth-graders failed the test—about 76,800 total students in 2008. On the one hand, the policy opened the opportunity of success for large numbers of students, particularly minority and low-income students, who are often denied access to advanced tracks even when they are prepared to succeed. On the other hand, it also set a large number of students on a course for failure without the adequate preparation or supports they would need to succeed in Algebra 1. Furthermore, students’ failure on the Algebra 1 CST tended to continue in subsequent attempts. In 2011, for example, only 20% of students who repeated the Algebra 1 course in ninth grade passed the test on their second attempt. This repeated failure may have convinced some students they are “unable” to understand and use mathematics, or ever complete the graduation requirement of passing the Algebra 1 CST.\(^\text{17}\)

Another central question in the policy debate in California is whether eighth grade is the appropriate target for enrollment of most or all students in Algebra 1. Enrolling students in Algebra 1 in eighth grade effectively requires “compressing” middle-grades topics into fewer grade levels of instruction. This may put underprepared students at a further disadvantage, as they have less time to learn the mathematics skills and concepts needed to become prepared for success in Algebra 1. Careful, equitable, and data-informed designation of which students are prepared to succeed in Algebra 1 in eighth grade is consequential. California schools that implemented such placement practices showed higher eighth-grade mathematics achievement overall.\(^\text{18}\)

Another consequence of mandating Algebra for All is its effect of reducing the academic rigor in many ninth-grade algebra classrooms. There is evidence that under policies...

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\(^\text{17}\) Rosin et al, *Algebra Policy in California*.

where all students are required to take Algebra, students are typically grouped according to ability, and most lower-track “Algebra 1” courses more closely resemble the remedial, pre-algebra courses that the policies were intended to eliminate in the first place.¹⁹ Students in these lower-achieving classrooms are typically exposed to watered-down curriculum, more slowly paced instruction, fewer advanced mathematics topics, and less emphasis on problem-solving approaches compared to their higher-achieving peers.²⁰ Further, students of color and economically disadvantaged students are disproportionately placed into such classrooms, where they typically experience reinforcement of negative perceptions about their ability and low expectations regarding their achievement.²¹

COMMON CORE STATE STANDARDS

The adoption of the Common Core State Standards for Mathematics (CCSS-M) by 45 states since 2010 has introduced a change in the algebra policy context. The CCSS-M describe the skills and knowledge that mathematics educators at all grade levels should seek to develop in their students. One of the major goals of the developers of the Common Core State Standards was to articulate fewer, more focused expectations for K-12 mathematics, which in turn resulted in some significant repositioning of content from previous grade-level and secondary-course standards. Several of these changes are consequential for the curriculum scope of Algebra 1. For example, much of the content previously addressed in Algebra 1 has been moved downward into the Grade-8 standards (see Table 1 for a summary of major shifts in algebra-related content in CCSS-M). In addition, the model Algebra 1 course outlined in CCSS-M includes a treatment of a limited number of advanced topics not typically addressed until Algebra 2 in previous state standards documents and curriculum materials. The combined result might be characterized as a slightly reduced, more focused scope of content for a ninth-grade Algebra 1 course, but with some increase in the level of advanced algebra content. On the one hand, the “slightly reduced” aspect may provide less-prepared learners the advantage of being able to focus on a somewhat smaller set of algebra concepts in ninth grade. In addition, as students progress through the mathematics curriculum over time, they may be better equipped to succeed in Algebra 1 because the standards also articulate a coherent set of algebraic and pre-algebra concepts throughout elementary and middle grades. On the other hand, downward positioning of algebra content means students are required to learn more demanding algebra content earlier, potentially increasing the challenge.

A final important issue related to CCSS-M is the articulation of expectations about mathematical practices—including sense-making, reasoning, constructing arguments, modeling, using appropriate tools, attending to precision, discerning patterns, and

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<th>Table 1: Major Shifts in Algebra Content in CCSS-M</th>
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<td><strong>CCSS-M Grade-8 Topics previously taught in a typical Algebra 1 course</strong></td>
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<td>- Linear functions – meaning and representations</td>
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<td>- Linear equation-solving</td>
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expressing regularity. The blueprint of the CCSS-M-aligned assessments, which are targeted to be implemented by 2014-15, indicates that these practices will be assessed at a level surpassing what has been seen in the past. As we will discuss later, the integration of these mathematical practices into Algebra curriculum will require an expansion from the traditional models of teaching Algebra 1.

Overall, it is still uncertain how implementation of CCSS-M and associated assessments will affect mathematics outcomes for students in grades eight, nine, and beyond, but they are cause for both optimism and concern about the readiness of students to succeed in Algebra 1, particularly those who have not traditionally been successful in mathematics under the previous, often less-rigorous standards and assessments.

**PRINCIPLES FOR IMPROVING STUDENT SUCCESS IN ALGEBRA**

Research on student success in algebra points to several ways in which algebra policies can be restructured to support student success more effectively. Given that Algebra 1 is a critical gatekeeper course for high school graduation and post-secondary success, and that CCSS-M has elevated the algebra standards for all students, we agree not just that all students take an Algebra 1 course (or its Integrated Mathematics equivalent) by ninth grade, but that the course reflects the rigor of a true college-preparatory mathematics approach to algebra, and further, that appropriate supports be included to help all students succeed in such a course. In light of the challenges this raises for underprepared students, this section offers three evidence-based principles for improving student success in Algebra and beyond.

**PRINCIPLE ONE: STUDENTS NEED EARLY, SYSTEMATIC EXPOSURE TO ALGEBRA**

In a traditional view of teaching algebra, algebra content is not addressed until a first formal Algebra course in eighth or ninth grade. This view is based on perceptions that algebra cannot be taught until particular prerequisite skills (e.g., percentages, decimals, fractions) have been mastered. For decades, however, the National Council of Teachers of Mathematics (NCTM)—and more recently CCSS-M—have promoted a vision of algebra teaching and learning that begins in pre-kindergarten and progressively expands in coverage and sophistication across the elementary and middle grades. Such early exposure to algebra is critical for student success in formal algebra courses in later grades.

Research indicates that early exposure to algebra has been linked to higher algebra performance. Key algebraic ideas to be developed through grades K-7 include the meaning and use of variables, the meaning of the equal sign as a “balance point”, generalizing arithmetic, generalizing patterns and rules for functional situations, and the equivalence of expressions. Given the importance of early algebra, if students are encountering algebra content for the first time in significant ways in eighth or ninth grade, the challenge and likelihood of failure increase. In addition, topics in the Number strand—proportional reasoning in particular—have been shown to be a gateway to the modes of abstraction prevalent in algebra. An evidence-based approach to improving success in Algebra would therefore start with ensuring a sound curriculum in K-8 mathematics, in alignment with the CCSS-M, and implemented with quality instruction, particularly in number and algebraic reasoning.

**PRINCIPLE TWO: UNDERPREPARED STUDENTS NEED TARGETED, STRUCTURED SUPPORT IN ALGEBRA 1**

In order for underprepared students to succeed at Algebra in eighth or ninth grade, they must be provided with targeted, structured

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22 Illinois will use assessments developed by the Partnership for Assessment of Readiness of College and Careers (PARCC). PARCC is a 22-state consortium working to developing K-12 assessments in English and mathematics.


CONSIDERATIONS FOR ALGEBRA IN 8TH GRADE

Completion of Algebra 1 in middle school creates opportunities for students to take more advanced mathematics courses in high school, including Advanced Placement courses in calculus and statistics. The number of students—including students of color and economically disadvantaged students—taking Algebra in 8th grade has increased dramatically over the past several decades. Enrollments vary by state, but nationally 8th graders today take Algebra more than any other mathematics course.1 This trend is supported in urban districts by efforts like the Chicago Algebra Initiative, which has helped open mathematics opportunities for algebra-ready middle school students to take a rigorous Algebra 1 course taught by a qualified teacher. Since 2003, the initiative has resulted in 225 credentialed teachers currently offering 8th grade algebra in 205 K-8 schools in Chicago.2

For students who are well prepared to succeed and who take the equivalent of a full, college-preparatory Algebra I course, placement in the course in 8th grade serves those students well.3 But districts and schools must carefully consider issues related to accelerating students into algebra in 8th grade. In cases where students are not academically prepared to succeed and/or the rigor of the courses is not strong, the consequences of taking the course too early are detrimental, and failure in the course sets students further behind rather than ahead.4 In 2002-03, for example, Charlotte-Mecklenburg schools dramatically increased the percentage of moderately-performing students enrolled in 8th grade Algebra, from less than half to nearly 90%. These underprepared students scored significantly lower on end-of-course Algebra I tests, and were either no more likely or significantly less likely to pass subsequent math courses.5

Students who are not prepared to take Algebra 1 in 8th grade are better served by a rich, demanding middle-school course in mathematics, one aligned to CCSS-M Grade-8 standards. In one study, low-achieving students (those with initial scores at or below the 20th percentile) attained higher tenth grade test scores if they took Algebra in high school, rather than in 8th grade.6

The percentage of students enrolled in 8th grade algebra is sometimes used as a metric to measure district or school achievement. The Illinois State Board of Education has recently added this metric to the State of Illinois school report cards. Given the findings related to success in 8th grade algebra being linked to students’ level of preparation, policies like this should be reconsidered. A possible consequence of such a policy is that schools might be influenced to enroll underprepared 8th-graders in the course in an attempt to display more favorable data.

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4 Loveless, Brown Center Report.
support. There is promising evidence that coupling a policy of requiring algebra for all students in ninth grade with the provision of additional instructional time can significantly benefit underprepared learners. In its less intensive forms, extra instruction may occur in the context of after-school programs that involve tutoring, additional practice, technology integration, algebra-related enrichment activities, or summer transition programs for entering ninth-graders. Examples of the latter include Portland Schools Foundation’s Ninth Grade Counts, which was found to have a clear, positive effect on high school credit attainment, and CPS’ summer intervention Step Up to High School program, which showed promise in improving students’ adjustment to ninth-grade Algebra.

A more intensive intervention, which is becoming increasingly prevalent in school districts nationwide, is to provide underprepared students (typically identified through use of assessment data, grades, teacher recommendations, or a combination thereof) with a second daily period of Algebra I instruction. Providing extra daily algebra instruction has resulted in some promising outcomes thus far. A study on the effects of one such policy enacted in CPS in 2003, for example, showed that underprepared students—in this case, those who scored in the lower 50th percentile on the eighth-grade Illinois Standard Achievement Test (ISAT) mathematics test—benefitted from the additional period of algebra instruction on various long-term metrics, including their ACT mathematics scores and reading scores, high school graduation rates, and college entrance rates. Other implementations of double-period algebra have resulted in substantial increases in overall algebra pass rates. A key aspect in each of these implementations was a sound process for identifying which students receive the additional instruction. Issues of available resources, need, potential benefit, and available data all factored into the criteria.

Extra time alone, however, is insufficient for meeting the expectations of policy makers, parents, and teachers for student learning—as well as those of students themselves. For many students, learning algebra involves overcoming a history of struggle in previous mathematics courses, which has left them multiple grade levels behind academically and discouraged emotionally. With so much additional ground to cover within a single year of instruction, a comprehensive, coherent system of supports is needed to exact the greatest benefit from the additional instruction. Drawing from research literature, a number of instructional approaches show promise for providing cognitive and socio-emotional supports for students who struggle with algebra. When coupled with the necessary extra time to implement them, these approaches can create an “architecture of support” that attends to the varied and significant instructional needs of students.

An appropriate architecture of support should include several...
elements. First, it should include curriculum and instruction aimed at reasoning, problem-solving, mathematical discourse, procedural fluency, sense-making, and application of concepts. Once thought appropriate only for selected high-achieving students, an approach that integrates higher-order mathematical practices has proved more effective than rote teaching of procedures for students across a wide spectrum of initial achievement levels, family income levels, and cultural and linguistic backgrounds.33 In addition, an effective architecture of support should involve an approach to algebra that helps students make sense of concepts and develop ways of thinking algebraically. In a functions-based approach, for example, the “function is the central concept around which school algebra curriculum is meaningfully organized.”34 A functions-based approach can help students access algebra more readily by building from students’ pre-existing number sense and abilities to recognize patterns. Another possible curricular approach is one that helps students understand algebra as generalized arithmetic. Also, a framework of support should incorporate distributed practice, or spacing practice problems in small doses over a long span of time.35 Finally, instruction that confronts and systematically exposes common mathematical misconceptions and errors—rather than avoids them—has been found to provide underprepared students with an efficient means of reviewing and repairing necessary prerequisite understandings for learning algebra.36

**PRINCIPLE THREE: INCREASING STUDENTS’ SUCCESS IN ALGEBRA REQUIRES ENHANCED TEACHING CAPACITY**

Teachers with more years of experience are generally more effective in helping students learn.37 However, administrators often assign the least-experienced instructors to teach Algebra 1, especially to sections of

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**Principle Three:**

**Increasing Students’ Success in Algebra Requires Enhanced Teaching Capacity**

Teachers with more years of experience are generally more effective in helping students learn. However, administrators often assign the least-experienced instructors to teach Algebra 1, especially to sections of...
underprepared learners, despite the well-established research about the critical role of algebra for students’ academic success, and the fact that teaching quality trumps virtually all other influences on student achievement. With regard to the teaching of algebra, a key to enhancing teacher quality is a commitment among both leadership and teaching corps to develop content knowledge and pedagogical skills that help struggling learners make sense of algebra. These capacities include deep understanding of algebraic reasoning, effective questioning strategies, implementation of rich mathematical tasks, establishment of an environment of mathematical exploration and discourse, analysis of student work, and using assessment to support student learning.

Teachers’ ability to address the social and emotional factors associated with learning mathematics is also related to struggling learners’ success in algebra. A characteristic of many schools and classrooms that are successful with helping underprepared learners is the use of an asset-based approach that builds on students’ strengths and helps them develop academic skills and identities. Students who have not experienced academic success often do not understand how “academics are played.” Teachers can explicitly teach skills that help students conceive of themselves as capable learners. In addition, fostering positive teacher-student relationships has been found to have a strong impact on attendance, pass rates, and grades for ninth-grade students in core academic classes.

In the same way that mathematical ability is not a fixed trait in students, these professional teaching capacities are not inherent abilities that some teachers possess and others do not. Rather, they can be developed through teacher preparation and ongoing professional learning. Enhancing teacher capacity in support of students’ success in Algebra requires consideration of policy development around two equally important aspects: (1) developing these capacities in teachers through teacher preparation, professional development, and evaluation; and (2) prioritizing Algebra 1 by assigning teachers who possess the capacities discussed above.

**RECOMMENDATIONS**

Several research-informed approaches can be implemented to improve current algebra policies. This section contains six recommendations that the State, local boards of education and district leaders, local school administrators and teaching corps, and leaders in teacher preparation programs, should consider.

**RECOMMENDATION ONE: PROVIDE ALL STUDENTS WITH A TRUE COLLEGE-PREPARATORY ALGEBRA COURSE BY THE END OF NINTH GRADE**

Replacing ninth-grade Algebra with remedial alternatives such as Pre-Algebra, basic math, algebra stretched over two years in grades nine and ten, etc., or else watering down content in courses named “Algebra 1” does not help students who are behind to catch up. Rather, it puts them further behind and makes it more difficult for students enrolled in these courses to meet their mathematics graduation requirements, and nearly impossible to go on to the advanced mathematics and science courses that pave the way to more promising post-secondary opportunities. Moreover, minority students and economically disadvantaged students are typically disproportionately placed into these less rigorous courses, thus amplifying the inequitable structures that persistently obstruct their opportunities in mathematics. Similarly, the programming and nomenclature of differentiated tracks of Algebra (e.g., Honors, Regular, Basic, etc.) perpetuate fixed beliefs among adults and


Content should reflect powerful algebraic ideas, which should not be delayed until students have “mastered the basics.”

In order to ensure that such an Algebra course meets the increased expectations of CCSS-M, the content should be strong in intellectual rigor and provide appropriate sense-making opportunities for students. Content should reflect powerful algebraic ideas, which should not be delayed until students have “mastered the basics.” The CCSS-M developers discuss rigor as promoting with equal intensity three aspects of learning: conceptual understanding, procedural skill and fluency, and application/modeling.

To support rigor in all Algebra courses, a careful selection process for the instructional materials should be adopted. The curriculum should include a coherent sequence of algebra concepts that aligns with the Algebra 1 expectations in the CCSS-M model courses; curriculum selection processes, however, should extend beyond a “checklist” approach of standards addressed to also include criteria that address the degree to which the materials address the CCSS-M Standards for Mathematical Practice.

RECOMMENDATION TWO: ENACT A K-8 MATHEMATICS CURRICULUM THAT PREPARES STUDENTS TO SUCCEED IN A HIGH-SCHOOL LEVEL ALGEBRA COURSE BY NINTH GRADE

School mathematics programs should carefully address mathematics ideas that research has shown are foundational for building algebraic understanding as they are articulated in the NCTM Principles and Standards for School Mathematics, and more recently, in CCSS-M. Students should begin to develop understanding about pre-formal algebraic ideas in early elementary grades and build up their algebraic knowledge and skills throughout the middle grades. Important algebraic underpinnings include proportional reasoning; the meaning and use of variables; the meaning of the equal sign as a “balance point”; generalizing arithmetic; generalizing patterns and rules for functional situations and the equivalence of expressions. Indeed, algebra should be conceived as a content strand that is developed across all grade levels. Moreover, math educators must be familiar with the standards across all grades, with a deep understanding of how algebraic concepts are developed in previous and subsequent grades.


44 For decades, NCTM principles and standards had advanced the development of algebraic concepts and skills throughout the K-8 mathematics curriculum. As states used the NCTM standards to develop their own mathematics standards, however, wide variation came to characterize what should be expected at each grade level, K-8, in the sub-strands of algebra (see Barbara Reys and Glenda Lappan, “Consensus or Confusion? The Intended Math Curriculum in State-Level Standards,” Phi Delta Kappan, 88, no. 9, (2007): 676-680). Through a clear articulation of algebra learning expectations in grades K-8, CCSS-M presents a means for districts and schools to build mathematics programs that better prepare students for Algebra 1. The PARCC assessments, in assessing foundational algebraic understandings via formative assessments in grades K-2 and via summative assessments in grades 3-8, will serve to focus attention on the need for a strong K-8 algebra strand.
RECOMMENDATION THREE: CAREFULLY ESTABLISH CRITERIA TO DETERMINE WHICH STUDENTS NEED EXTRA SUPPORT TO BE SUCCESSFUL IN ALGEBRA

Careful criteria should be used to identify which students should receive targeted, structured support. In cases where no systematic, multi-faceted process is in place to identify these students, an identification system should be built. This system should involve multiple sources of evidence, such as seventh- and eighth-grade mathematics grades; mathematics assessment data (e.g., ISAT scale scores and performance-level descriptions); algebra readiness tests; teacher recommendations; and student self-assessments.

The process should be flexible enough to involve some degree of student and parent choice, and it should be well-documented, openly communicated, and frequently reviewed and adjusted to increase its effectiveness. The process should also avoid over-tracking and overly-rigid placement criteria by allowing motivated and resilient students, perhaps with parent consent, to opt out of a suggested placement if there is indication from previous coursework or teacher recommendation that they can succeed.

RECOMMENDATION FOUR: PROVIDE TARGETED, STRUCTURED SUPPORT TO UNDERPREPARED STUDENTS

Underprepared students should be provided with additional instructional time to help them succeed in Algebra 1. Double-period algebra classes can provide necessary, structured support with the explicit goal of helping underprepared students, over the course of a year, catch up to their peers so that they can succeed in future on-level mathematics and science courses. Summer transition programs (eighth grade to ninth grade) and after-school programs offer additional opportunities for support.

Given that more time is important but not enough, the extra time should be used well. A coherent set of instructional materials and instructional practices should incorporate the following key aspects to provide appropriate instructional supports for underprepared students: (1) Use of curricular approaches that help students make sense of algebraic concepts and ways of thinking (e.g., a functions-based approach, algebra as generalized arithmetic, conceptual development through use of rich problems); (2) emphasis of the CCSS-M Standards for Mathematical Practice; and (3) use of routines and structures that support students’ learning and retention of algebraic ideas and skills (e.g., worked examples, spaced practice, tasks and activities that help students build on prior knowledge and repair existing misconceptions).

RECOMMENDATION FIVE: ASSIGN NINTH-GRADE ALGEBRA COURSES TO TEACHERS MOST QUALIFIED TO TEACH THE COURSE—PARTICULARLY WHERE UNDERPREPARED LEARNERS ARE ENROLLED

Because Algebra 1 is such a high-stakes course, school administrators should make it a top priority in making teacher assignments. Teachers who are most qualified to teach the course should be assigned to teach Algebra 1. Experience, math background, teaching abilities, and teacher dispositions should all be considered in this process. Indeed, high student-to-teacher ratios in Algebra 1 compared with other mathematics courses are typical in most districts and schools. Because of the critical importance of Algebra 1 and its implications for keeping students on track to graduate, district and school decision makers should look to reverse this situation to allocate resources where they are most

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45 We make this recommendation acknowledging that extended-time algebra classes place demands on district, school, and student resources. However, we advance this recommendation based on recognition of the critical importance of students’ succeeding in Algebra 1 and the negative consequences of high failure rates in Algebra 1, which include the associated costs of remediating students who fail the course.
needed. Assigning the most-qualified teachers to teach Algebra 1 may involve confronting an established merit system, where more experienced teachers “earn the right” to teach the advanced and/or upper-level courses.

RECOMMENDATION SIX: ENHANCE TEACHERS’ CAPACITIES TO PROVIDE HIGH-QUALITY MATHEMATICS INSTRUCTION AND SUPPORT THE NEEDS OF UNDERPREPARED STUDENTS IN ALGEBRA

A program of professional learning should support algebra teachers’ domain-specific content knowledge (e.g., the different meanings and uses of variables; varied methods for solving algebraic problems; distinct properties of number systems) and pedagogical content knowledge (e.g., ways to address common algebraic misconceptions, connect mathematical ideas together, decide which instructional strategies are most effective for particular concepts, and assess particular algebraic understandings). Enhancing these capacities becomes particularly important in light of the changes in course content and emphasis on mathematical practices brought about by CCSS-M.

Preservice and inservice professional learning should also include an aspect to help teachers build their capacity to positively enhance students’ academic identities and dispositions toward learning. Social-motivational supports and ideas from social psychology can be incorporated into the fabric of an Algebra 1 course, especially in courses with a high percentage of students who have traditionally not succeeded in mathematics. Moreover, the explicit teaching of the role of effective effort and the theory of malleable intelligence (i.e., that one’s intelligence is not fixed) has been linked to increases in student’s persistence, willingness to take academic risks, and academic performance. 46

CONCLUSION

Successful completion of Algebra 1 continues to be a key benchmark toward attaining a high school diploma and preparing students to take more advanced mathematics courses. Enacting Algebra for All policies and aligning algebra content to CCSS-M both serve the purpose of raising expectations for all students with regard to meeting this benchmark. However, for these policies to be meaningful with regard to students’ actual academic trajectories, completion of Algebra 1 must be timely, the content of the course must be rigorous, and supports for underprepared students must be sufficient to provide them with a pathway toward success. This requires a carefully planned, systemic approach that considers the potential impact of the existing K-8 mathematics curriculum, extra instructional time with targeted supports in grade nine, and the teaching capacity required to provide high-quality instruction in Algebra 1.

ABOUT US

The Research on Urban Education Policy Initiative (RUEPI) is an education policy research project based in the University of Illinois at Chicago College of Education. RUEPI was created in response to one of the most significant problems facing urban education policy: dialogue about urban education policy consistently fails to reflect what we know and what we do not about the problems education policies are aimed at remedying. Instead of being polemical and grounded primarily in ideology, public conversations about education should be constructive and informed by the best available evidence.

OUR MISSION

RUEPI’s work is aimed at fostering more informed dialogue and decision-making about education policy in Chicago and other urban areas. To achieve this, we engage in research and analysis on major policy issues facing these areas, including early childhood education, inclusion, testing, STEM education, and teacher workforce policy. We offer timely analysis and recommendations that are grounded in the best available evidence.

OUR APPROACH

Given RUEPI’s mission, the project’s work is rooted in three guiding principles. While these principles are not grounded in any particular political ideology and do not specify any particular course of action, they lay a foundation for ensuring that debates about urban education policy are framed by an understanding of how education policies have fared in the past. The principles are as follows:

• Education policies should be coherent and strategic
• Education policies should directly engage with what happens in schools and classrooms
• Education policies should account for local context

RUEPI policy briefs are rooted in these principles, written by faculty in the University of Illinois at Chicago College of Education and other affiliated parties, and go through a rigorous peer-review process.

Learn more at www.education.uic.edu/ruepi

This brief, Algebra and the Underprepared Learner, was developed in cooperation with the Chicago STEM Education Consortium (C-STEMEC). C-STEMEC comprises four STEM-related university centers: the Center for Elementary Mathematics and Science Education at the University of Chicago, the Loyola Center for Science and Mathematics Education at Loyola University, the Learning Sciences Research Institute at the University of Illinois at Chicago, and the STEM Center at DePaul University. Support for C-STEMEC comes from the Searle Funds at The Chicago Community Trust.